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Solar AC Generator without Inverter

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ABSTRACT: Today, a majority of the world's energy needs are met by fossil fuels and as the global energy consumption increases drastically so does the consumption of fossil fuels. But fossil fuels being a non-renewable resource is on the verge of depletion and hence arises the need for the use of renewable energy resources. The project undertaken, puts forward an innovative means of generating power from solar energy using solar panels by directly generating AC power, unlike the conventional systems which generates DC power which has to be further on converted to AC. This new system, removes the need for inverters and phase synchronizers, the losses caused by the power electronic converters and need for batteries. Making the system more cost effective, efficient and practical. The system use an array of photovoltaic cell pairs which are connected in antiparallel form to create an AC wave form. The frequency of the AC output generated by these cells as they are alternatively covered and exposed to solar incidence under a rotating disk can be controlled, by simply controlling the speed of the motor used to rotate the disk.

KEYWORDS: Solar, AC Power, Disk, Photovoltaic, Frequency

I. INTRODUCTION

The requirement of renewable energy is increasing as the worldwide climate is changing day by day. Coal and other fossil fuels are also limited and they will ultimately run out. The hydroelectric power can be a limited source of energy it can only be used in places with huge water resources. Then nuclear energy can also be used for the generation of electricity but it can create nuclear waste so it is not environmental friendly. Though, the use of clean renewable energy in the form of solar energy is possible. It is a regular resource of clean energy as sun shines everywhere in the planet. So it is easy to convert solar energy into electricity using a solar cells. Solar power is anticipated to become the world's largest source of electricity by 2050, with solar photovoltaic and concentrated solar power contributing 16 and 11 percent to the global overall consumption. A Photovoltaic cell is made up of a semiconductor material like silicon. It absorbs the sunlight and produces electricity. Electron can only flow in a one direction through a solar cell because the terminals (positive and negative) of the solar cell are static. That's why solar cell can only produce direct current (DC)[1].

The primary issue with solar power generation is that, solar panels today produce DC power which has to be converted to AC as a majority of the electrical devices can only use alternating current (AC). The price of solar panels combined with the price of inverters, phase synchronizers, installation and maintenance has made the price of solar prohibitive. Add to that the loss of power from the different components used in the DC to AC conversion process and it becomes even more unattractive. Today, AC power is produced for the power grid by AC generators. The generators are powered by mechanical energy provided by water turbines or steam turbines, natural gas or nuclear fuel. The mechanical energy rotates the coils of the generator in a magnetic field to produce voltage. Because the conductor coil of the generator flips direction during rotation in the magnetic field the resulting voltage produced is sinusoidal or AC. This project eliminates the problem of converting DC to AC. It uses solar as its input and with the help of a motor-disc arrangement it converts the DC power of solar cells directly to AC without use of any conversion equipment. The resulting output voltage is thus sinusoidal or AC. Thus there is no need of conversion equipment's such as inverters, phase synchronizers etc. This makes the overall concept quite simple yet effective and economical as well[5]. And, these solar AC electricity generator arrays can easily replace the power plants today, at the same time being nature

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friendly, they can be located anywhere like in a playground, school or in any residential or in any urban surroundings. Large scale solar AC electricity generator arrays can easily be placed in any remote place.

II. RESEARCH OBJECTIVE

The primary objective is to eliminate the need of the converter systems which include power electronic components and hence inefficiencies brought about by this extra instrumentation which at present is necessary for conversion of the DC output of the solar system to an AC output. The Solar AC Generator can provide the same result at lower price and with even less energy losses just by producing alternating current directly from solar cells without using extra circuitry. Thus making solar energy a practicable, cheap, environmental friendly for commercial and domestic use. And, making it capable to be used in both the small or large scale by suitable scaling the solar AC electricity generator [1].

III. LITERATURE SURVEY

- [1] Jason Allen Oliver, "Device, System and Method for Directly Generating Alternating Current Electricity from Photovoltaic Cells",
[2] Muhammad Aziz Ul Haq, Hifsa Iram, Azaz Ul Haq, "Smart Solar AC Generator without Inverter"
[3] Reference Book:-B.L. Theraja, A. K. Theraja, Textbook of Electrical Technology", AC and DC Machines

The present invention is a system, device and method for directly generating alternating current electricity from photovoltaic cells. The system, device and method mechanically gradually exposes and shades photovoltaic cell pairs connected in anti-parallel to sunlight to generate alternating current electricity at an AC junction of the solar cell pairs. Gradually and alternately exposing and shading the two anti-parallel connected solar cells of each solar cell pair causes the amplitude and polarity of the electricity at the AC junction to gradually rise and fall to produce alternating current electricity. The gradual, alternating exposure and shading of the two anti-parallel solar cells is accomplished by mechanically covering and exposing the solar cell pairs. In particular, while one solar cell of an anti-parallel connected solar cell pair undergoes gradual exposure to sunlight from 0% exposure (100% shaded) of the solar cell electricity generating area to 100% exposure (0% shaded) of the solar cell electricity generating area, the other solar cell of the solar cell pair undergoes gradual shading from sunlight from 0% shaded (100% exposure) to 100% shaded (0% exposure). Such gradual, alternating exposure and covering of each solar cell of each antiparallel connected solar cell pair is periodic. The rate of exposure and shading determines frequency. In one form, a rotating disc situated over the solar cell pairs has spaced apart openings forming coverings between each opening to alternately expose and shade the solar cell pairs during rotation. A direct current motor is utilized to rotate the segmented disc. The motor is preferably powered by separate solar cells. The present invention also provides a phase synchronizer for maintaining a desired alternating current frequency. The phase synchronizer controls the motor to control rotation of the segmented disc

IV. SOLAR AC GENERATOR WITHOUT INVERTER

The Solar AC Generator without an Inverter comes as a practical, cheap, and environmental friendly unit for commercial as well as domestic use. It can be efficiently put to use for commercial as well as domestic usage and has the capacity to replace the existing power plants and can be placed at almost any place like a playground, school or in any residential or in any urban surroundings

Disc Arrangement

The solar cells are arranged in such a way that it gives us the output in sinusoidal form. The solar cell ac electricity generator has a base that supports the various components there. The base may be formed of wood, plastic or other suitable material which is preferably, but not necessarily, a non-conducting material. The base includes an alternating current electricity production portion formed by a disc and a plurality of photovoltaic or solar cells [3].

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Vol. 8, Issue 5, May 2019

As best seen in Figure, the plurality of solar cells are arranged in a generally circular array on an upper surface of the base. It should be appreciated that arrays other than circular may be used within the present principles. It should also be appreciated that while the solar cells are shown as rectangles, the size and shape of the solar cells may be otherwise, such as truncated conical, triangular, polygonal or square. As best seen in Figure (a) and (b), the disc has a generally at body made of a sunlight blocking material that is generally the circumference of the solar cell array in order to extend over the solar cell array when in use. The disc is also preferably made of a lightweight material that resists warping or is not susceptible to warping. It should be appreciated that the disc may be partially reflective or non-reflective if desired.

Panel arrangement and connection

A pair of solar cells A and B is shown in the Figure (c). To generate an AC output wave the solar cell pair is connected in anti-parallel. The negative terminal of the photovoltaic cell A is connected with positive terminal of the photovoltaic cell B, whereas the negative terminal of the solar cell B is connected to the positive terminal of the photovoltaic cell A. The solar cell pair should be connected as shown in the figure (c). The AC output terminals are Aout and Bout. To increase the current and maintain the constant voltage, the solar cells shown are connected in parallel. In order to increase voltage and to maintain constant current, solar cells would be connected in series.

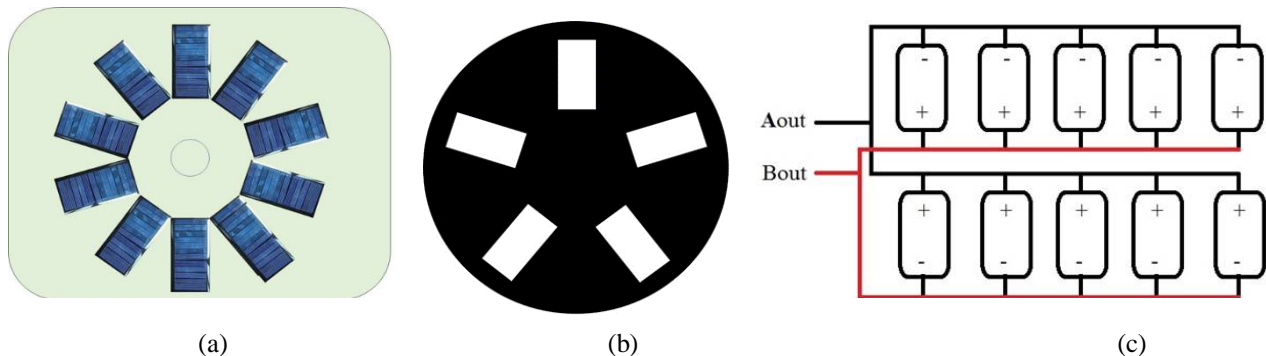


Figure (a) (b) (c) Panel and Disc Arrangement

An array of solar cells is connected for AC sine wave. The solar cells on the upper side are represented by solar cells A1, A 2, A3, A4, and A5 are coupled to form the single AC output terminal Aout, while the remaining solar cells represented by solar cells B1, B2, B3, B4, and B5 are coupled so that they can form the single AC output terminal Bout hence forming a "photovoltaic cell pair". Each solar cell pair of them has the first and second AC output is connected in anti-parallel to form a single AC output. So one output terminal would provide the single phase AC electricity [4].

Method of Directly Generating AC

The process of generating alternating current from the photovoltaic cell pairs mechanically exposes and shades solar cell pairs that are connected in anti- parallel. So expose and shade the solar cells alternately and gradually of all solar cell pairs that are connected in anti-parallel to vary the amplitude and polarity to form AC wave, which is done by mechanical Stage 1 shows the negative peak of the voltages because the solar cell A is covered so it is giving 0 volts and solar cell B is exposed so it is giving the peak voltages. As the B cell is connected in opposite direction so its peak voltage will be considered as a negative peak.

Stage 2 illustrates the second condition when both the cells are half covered. So they both will give the half of their maximum output so now at that time they both will cancel the effect of each other so the output current will be zero.

Stage 3 is a third condition in this cell A is fully exposed and cell B is fully covered so cell A will give its maximum current and cell B will give 0 current. As cell A is making the positive terminal so this condition will give the positive peak. As shown in the graph as well.

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Vol. 8, Issue 5, May 2019

Stage 4 is a fourth condition. It is similar to that of second condition. Both A and B cell are half covered and so they will cancel the effect of each other and there will be no current in the output.

Stage 5 shows the fifth condition it is similar to that of first condition. Cell B is fully exposed and cell A is fully covered give the negative peak as shown in the graph. So now by combining these 4 conditions we can see that how are AC signal is generated using the setup[1][5].

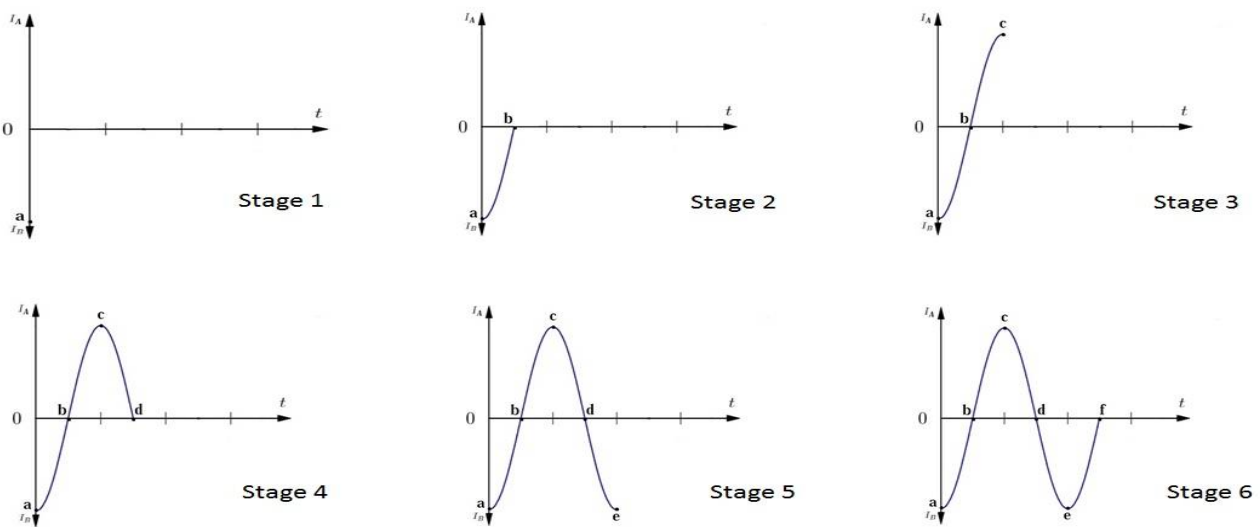


Figure (d) Output waveforms of different stages

Layout and Working

Existing technology requires solar energy to be converted from direct current (DC) to alternating current (AC) before it is compatible with the nation's power grid. This method of generating AC power directly solar energy seeks to achieve the same result at a lower cost and with less energy loss by producing alternating current directly instead of relying on additional equipment [8].

In this system, an even number of solar panels connected in anti-parallel are arranged in a circular manner over a wooden base, which is a non-conducting material. Solar cells are placed in a circular form so that the pair of anti-parallel connected photovoltaic cells of each photovoltaic cell pair progressively and alternately get exposed and shaded causing the amplitude and polarity of the waveform at the AC output to slowly and steadily rise and fall to make alternating current.

A motor (preferably dc motor) fixed at the center of the base is used for rotating the upper disk. And, the disk can rotate in either direction that is, clockwise or anticlockwise. The direction of rotation of the disk depends on the polarity of the motor. The upper disk consists of slots, the number of slots being half the number of panels. And hence, the pair of photovoltaic cell pair progressively and alternatively get exposed and shaded causing the amplitude and polarity of waveform at the AC output to slowly and steadily rise and fall to make alternating current[1][6]. The block diagram of the solar AC generator without inverter is shown in figure (e).

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Vol. 8, Issue 5, May 2019

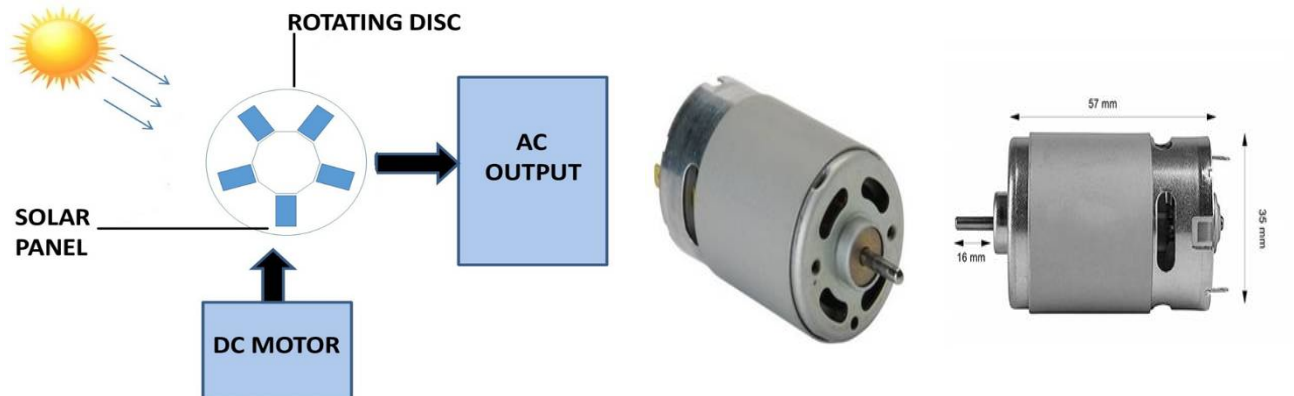


Figure (e) Block diagram Figure (f) DC Motor

V. DESIGN PARAMETERS AND COMPONENTS

The major components used in this system are solar panels and DC motor

Design of frequency

The frequency of the AC output must be of 50Hz (ideally) so that it can be directly connected to the grid or used to directly supply domestic AC loads [7].

This frequency which is dependent on the speed of rotation of the upper disk. The speed- frequency relation is given by the equation,

$$N=120f/P$$

Where,

f is the frequency in Hz,

N is the number of revolutions per min (rpm)

P is the number of poles.

Here, N is the speed of rotation of the upper disk (in rpm) and P is the total number of solar panels. Where, each North pole is formed by the positively connected panel and each South pole is connected by the negatively connected panel.

In order to rotate the disk at a desired speed so as to avail the desired frequency (50Hz) a suitable DC motor of suitable rating has to be selected.

We know, $f= 50\text{Hz}$ and fixing $P= 10$ (to limit speed requirement)

$$N = 120 * 50 = 600\text{rpm}$$

Hence, the required speed of rotating disc is 600 rpm.

DC motor

The DC motor used to rotate a segmented disc which is placed in front of array of solar cell. A machine that converts DC electrical power into mechanical power is known as a Direct Current motor. DC motor working is based on the principle that when a current carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force. When the conductor (armature) is supplied with a current, it produces its own magnetic flux. This motor will drive the disc at a constant speed. This motor will be supplied from a variable power supply. Here, a 2000 rpm DC motor has been used to rotate the segmented disc. Prescribed DC motor is shown in the Figure (f).

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Vol. 8, Issue 5, May 2019

Solar Panel

Solar panels collect clean renewable energy in the form of sunlight and convert that light into electricity which can then be used to provide power for electrical loads. Solar panels are comprised of several individual solar cells which are themselves composed of layers of silicon, phosphorous (which provides the negative charge), and boron (which provides the positive charge). Solar panels absorb the photons and in doing so initiate an electric current. The resulting energy generated from photons striking the surface of the solar panel allows electrons to be knocked out of their atomic orbits and released into the electric field generated by the solar cells which then pull these free electrons into a directional current. This entire process is known as the Photovoltaic Effect. The specifications of the solar panels (Figure (g)) used in the construction of the prototype of solar AC generator without inverter is given in Table 1.

Table 1. Specifications of one solar panel

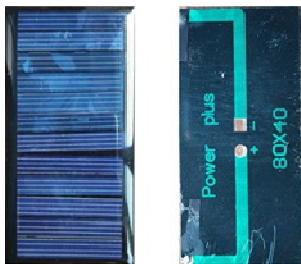


Figure (g) Solar panel

Material	Monocrystalline Silicon
Shape	Rectangle(80mm*40mm)
Number of cells	10
Max Output voltage	6V
Max Output Current	60mA

VI. EXPERIMENTAL SETUP WITH RESULT

Model Layout

The practical model of the prototype used a wooden sheet as base which is a non-conducting material. The solar cells are arranged in a circle on the surface of the base. And the motor is at the center of base which is rotating the spinning disk [6].

A non-elastic disk made of form board having same or more diameters than the solar cell array which covers the whole solar cell array and it can expose and block the sun light. The disc should be of a lightweight material with no elasticity so it can easily rotate. The disc has 5 slots. The size and shape of the holes are same as that of the photovoltaic cell array to control exposure of photovoltaic cell to the sunlight when the holes are placed over the solar cell. Rest of the sheet is used to completely cover a solar cell when the hole is not over the solar cell.

The holes are located at about 144 degree from each other. The number of holes is 5 so that the number of coverings is half the number of photovoltaic cells. So, when the disc is placed on the frame above the photovoltaic cell array, half of the solar cell array area is exposed and half of the solar cell array area is covered. When the disc rotates over the array of solar cells, it will slowly and constantly covers and exposes the array of photovoltaic cells by the cutouts and coverings [3]. After designing the base, rotating disk and making all the connections, the AC solar generator looks like shown in figure below. A DC motor that is supported by the base rotates the disc above the base consisted of solar cell array. Rotation can be in any direction clockwise or counter clockwise. Rotation of the disc causes the cutouts to alternately cover and expose the neighbouring photovoltaic cells. The frequency of the signal depends on the speed of the rotating disk. Faster the photovoltaic cells are covered and exposed, the higher the frequency of AC electricity produced and vice versa. A variable power supply is used to supply the DC voltages to the DC motor which will then rotate the disk to produce AC waveform.

International Journal of Innovative Research in Science, Engineering and Technology

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Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019



Figure (h) Model lay out and testing

Result

Mechanically exposing and covering the photovoltaic cell pairs gradually, alternating expose and cover the two anti-parallel solar cells. It results in a sinusoidal AC wave form. The resulting sine wave is periodic. The rate at which the exposing and shading is done determines the frequency of the sine wave. Frequency plays most important role in this experiment, as load side must requires 50Hz whatever the variation in waveform of voltage happens.

Frequency is affected by only speed of the rotor. As speed increases, frequency increases and vice-versa. Frequency of the output power can be measured either by multimeter or by DSO. At the end of experiments, a frequency of 49.5Hz was received.

Given below (Table 2) are the output measurements availed from the Solar AC generator without inverter via a DSO.

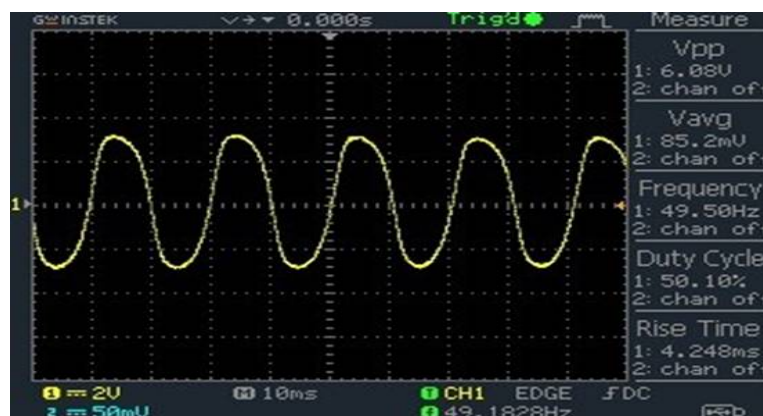


Figure (i) DSO Output waveform

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Vol. 8, Issue 5, May 2019

Table 2. Measurements of AC solar generator

Peak-to-peak voltage	6.08V
Average voltage	85.2mV
Rise time	4.248ms
Frequency	49.5Hz
Max Output Current	60mA

VII. CONCLUSIONS

A Solar AC Generator without Inverter, has been studied and implemented. Its advantages include the removal of the inverter circuit, and hence decreasing the cost and improving efficiency of the system. Other benefits: (i) generation of free energy from the sun (ii) non-polluting energy reduces emissions that is, has as no direct impact on the environment (iii) its easily scalable (iv) grid-tie systems will allow you to sell excess electricity back to the utility (v) can be installed and operated anywhere including areas of difficult access and remote locations (vi) helps to get off dependence on foreign oil (vii) PV cells make no noise and give off no exhaust.

The prototype was designed using ten mini solar panels and a suitable DC motor was then used to rotate the segmented disk. The output of the same was then given to a DSO and a voltage waveform of approximately 49.5Hz was obtained. A peak to peak voltage of 6.08V was received, which is the voltage rating of each of the ten solar panels connected in antiparallel mode. The prototype is meant to show the concept in practical use but however isn't the most efficient way the technology could be applied. Given the right manufacturing technology the solar cells could be made in the shape of a pie wedge. When arranged in a circle next to each other they could generate power from the entire area under the rotating disk and not just a portion of the area as shown in the prototype. The optimum size might be about the same size as a compact disk. Generation of solar energy has tremendous scope in India. The geographical location of the country stands to its benefit for generating solar energy. The reason being India is a tropical country and it receives solar radiation almost throughout the year, which amounts to 3,000 hours of sunshine. If solar AC generators capable of generating large power are made, we can reduce the dependency on other power plants. Thus we can reduce the generating cost to a great extent.

VIII. FUTURE SCOPE

The prototype is meant to show the concept in practical use and however it isn't the most efficient way the technology could be applied. Given the right manufacturing technology the solar cells could be made in the shape of a pie wedge. When arranged in a circle next to each other they could generate power from the entire area under the rotating disk and not just a portion of the area as shown in the prototype. The optimum size might be about the same size as a compact disk. Generation of solar energy has tremendous scope in India. The geographical location of the country stands to its benefit for generating solar energy. The reason being India is a tropical country and it receives solar radiation almost throughout the year, which amounts to 3,000 hours of sunshine. If solar AC generators capable of generating large power are made, we can reduce the dependency on other power plants. Thus we can reduce the generating cost to a great extent.

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Vol. 8, Issue 5, May 2019

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